INFORMATION RECORD APPARATUS, INFORMATION RECORD METHOD, AND INFORMATION RECORD MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an information record apparatus for performing power calibration when recording information on an optical information record medium such as a write-once optical disk or a rewritable optical disk, for example.

2. Description of the Related Art

In recent years, in addition to read-only CD (compact disk) and DVD (digital video disk or digital versatile disk), write-once (recordable) CD and DVD, rewritable CD and DVD, MD (mini disk), and the like have been developed for increasing the number of variations of the optical information record media.

In write-once (recordable) CD and DVD, which will be hereinafter collectively called write-once optical disk, write laser light is applied to a record film of an organic coloring matter material for forming record pits, thereby irreversibly recording information. In rewritable CD and DVD, which will be hereinafter collectively called rewritable optical disk, write laser light is applied to a phase change film for repeating crystallization and rendering amorphous, thereby reversibly recording information as circular or elliptic record pits. In

MD, magneto-optical recording is performed.

In an information record apparatus in a related art, to form a record pit in appropriate form in the write-once optical disk and rewritable optical disk for recording information, power calibration is conducted to adjust the emission power of a semiconductor laser for emitting write laser light, placed in a pickup at the setup time before essential information recording is performed.

In the power calibration, record pits are formed in a power calibration area provided at the inner radius of an optical disk and the emission power of the semiconductor laser is optimized based on the waveform provided, for example, by AC coupling a detection signal, called HF signal, provided by optically reading the record pits formed (namely, written for a try) in the power calibration area.

That is, as with the case where normal information reading is executed, reflected light from the power calibration area in which the record pits are formed is detected by a photodetector and outputs of the photodetector are combined, whereby the HF signal is generated. This means that the HF signal is a signal before equalizing to generate an RF signal, etc., is performed.

As the HF signal is thus generated, an eye pattern of the HF signal is provided. If the waveform is AC-coupled, top peak level a1 of the waveform indicates the potential difference between the potential indicating the strength of reflected light

from a land where no record pit is formed and the potential of AC ground GND and bottom peak level a2 indicates the potential difference between the potential indicating the strength of reflected light from a record pit and the potential of AC ground GND, as shown in FIG. 7 (A).

The ratio between the peak-to-peak value of the HF signal (a1+a2) and the difference between the levels (a1-a2), which will be hereinafter referred to as β value, is found as shown in the following expression (1), and, for example, when β value=0 is adopted as the target of the power calibration, if the β value becomes almost 0, it is determined that the emission power P of the semiconductor laser is equal to target power Pw; if the waveform provided by AC coupling the HF signal becomes the waveform shown in FIG. 7 (B) and the β value becomes a negative value, it is determined that the emission power P of the semiconductor laser is smaller than the target power Pw; and if the waveform provided by AC coupling the HF signal becomes the waveform shown in FIG. 7 (C) and the β value becomes a positive value, it is determined that the emission power P of the semiconductor laser is larger than the target power Pw. The emission power P of the semiconductor laser is adjusted so as to become equal to the target power Pw based on each determination result.

$$\beta = (a1-a2)/(a1+a2) \qquad (1)$$

Further, as a more specific example, the power calibration in the related art for CD-R will be discussed with reference to FIGS. 8 and 9.

In CD-R, as shown in FIG. 8 (A), a power calibration area PCA made up of a test area TA and a count area CA is previously allocated; the test area TA is an area for forming a record pit as trial write and the count area CA is an area to count the number of write times into the test area TA to locate the portion to execute trial write in the test area TA.

In the information record apparatus in the related art, as shown in a flowchart of FIG. 9, first a search is made for the write location of the count area CA (step S200) and a record to check the number of write times into the test area TA is entered in the write location (step S202) and then the pickup is moved to the location corresponding to the write location into the count area CA in the test area TA (step S204).

Next, the emission power P of the semiconductor laser is changed at n steps of recommended power as shown in FIG. 8 (B), whereby record pits REC at n steps are written for a try into a predetermined portion of the test area TA as shown in FIG. 8 (C) (step S206). That is, the emission power P is changed every predetermined time τ, whereby the record pits REC at n steps corresponding to the n steps of the emission power P are written for a try.

Upon completion of the trial write, the record pits REC at n steps are optically read with the pickup to detect HF signals corresponding to the record pits at n steps (step S208).

Next, the calculation of the expression (1) shown above is performed based on each of the HF signals, whereby n β values (β1 to βn) are found (step S210) and whether or not a target β value is contained in the range of the β values (β1 to βn) is determined (step S212).

If the target β value lies in the range, the β value closest to the target β value is found and the emission power P corresponding to the β value is adopted as optimum power Popt for setting the emission power of the semiconductor laser (step S214) before the essential information recording is started.

If the target β value does not lie in the range, the n steps of the emission power are finely adjusted (step S216) and a search is made for a new data write location of the count area CA (step S218) and step S202 and the later steps are repeated. If the target β value is contained in the range at step S212, the power calibration is completed.

[Problems to be Solved by the Invention]

However, the power calibration in the related art requires a long time in optimizing the emission power of the semiconductor laser, prolonging the setup time before the essential information recording is started.

That is, as shown in FIGS. 8 (B) and 8 (C), if the emission

power of the semiconductor laser is changed at n steps for forming the record pits REC, the portion into which the record pits REC are written becomes a long duration of n X τ. Thus, for example, if eccentricity or side run-out occurs on the optical disk during the trial write, adversely affected record pits REC are written and if the portion into which the record pits REC are written is read and β values are found, it is made impossible to provide the β values corresponding to the record pits at n stages ($\beta 1$ to βn) with good accuracy. Thus, as shown in the flowchart of FIG. 9, processing is repeated a large number of times until the β value equal to the target β value is provided, and the setup time is prolonged; this is a problem.

If eccentricity, side run-out, etc., occurs on the optical disk during the trial write and adversely affected record pits REC are written, the emission power of the semiconductor laser is optimized based on erroneous β values, namely, erroneous adjustment occurs and it becomes difficult to maintain and improve the accuracy of the power calibration; this is a problem.

Further, for an unrewritable optical information record medium, the power calibration are is limited and if a large area used for one power calibration is taken, the remaining number of power calibration use times is reduced; this is also a problem.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an information record apparatus and an information record method for making it possible to overcome the above-described problems and improve the accuracy of power calibration.

It is another object of the invention to provide an information record medium recording control information to improve the accuracy of power calibration for controlling an electronic machine based on the control information.

To the end, according to the invention, there is provided an information record apparatus for adjusting power of write light onto an optical information record medium, the information record apparatus comprising a light source for emitting the write light, a power adjustment section for adjusting the emission power of the write light, a write section for recording a record pit in the optical information record medium by applying write light emitted from the light source, a feature extraction section for extracting feature information of the record state containing the recorded record pit based on the signal waveform provided by optically reproducing the record state from the optical information record medium in which the record pit is formed, and a control section for causing the power adjustment section to adjust the emission power of the write light based on the feature information provided by the feature extraction section, characterized in that the write section records a record

pit in the optical information record medium by applying write light of predetermined power emitted from the light source, the feature extraction section extracts the feature information of the record state containing the recorded record pit based on the signal waveform provided by optically reproducing the record state, and the control section sets write light of a plurality of steps of power in the power adjustment section based on the feature information, then the write section records record pits at a plurality of steps in the optical information record medium by applying the write light of the plurality of steps of power, the feature extraction section extracts the feature information of the record state for each of the record pits at the plurality of steps based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, and the control section determines that power of write light corresponding to the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is appropriate write light power, and causes the power adjustment section to adjust the emission power of the write light.

In the information record apparatus, the write section records a plurality of sets of record pits at a plurality of steps in the optical information record medium by applying the write light of the plurality of steps of power, the feature

extraction section extracts the feature information of the record state for each of the record pits in the plurality of sets and at the plurality of steps based on the signal waveform provided by optically reproducing the record states containing the plurality of sets of the recorded record pits, and the control section finds average feature information of the record state for each of the record pits at the plurality of steps, determines that power of write light corresponding to the information closest to or almost equal to the target feature information, of the average feature information is appropriate write light power, and causes the power adjustment section to adjust the emission power of the write light.

According to the information record apparatus having the configuration, a record pit is recorded in the optical information record medium by applying write light of predetermined power, the feature information of the record state is extracted based on the signal waveform provided by optically reproducing the record pit in the record portion, and write light of a plurality of steps of power is set based on the feature information. Next, record pits at a plurality of steps are recorded in the optical information record medium by applying the write light of the plurality of steps of power, the feature information of the record state for each of the record pits at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states

containing the record pits at the plurality of steps, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is appropriate write light power, and the emission power of the write light is adjusted.

Thus, trial write onto the optical information record medium is executed by applying the write light of the predetermined power, whereby write light of the plurality of steps of power for trial write to determine appropriate write light power are determined, and trial write onto the optical information record medium is executed by applying the write light of the plurality of steps of power, the feature information of the record state for each of the record pits at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is the appropriate write light power, and the emission power of the write light is optimized, so that the time required for the power calibration can be shortened.

A plurality of sets of record pits at a plurality of steps

are recorded in the optical information record medium by applying the write light of the plurality of steps of power, the feature information of the record state for each of the record pits in the plurality of sets and at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states containing the plurality of sets of the recorded record pits, average feature information of the record state for each of the record pits at the plurality of steps is found, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the average feature information is appropriate write light power, and the emission power of the write light is optimized.

The appropriate write light power is determined based on the average feature information of the record state for each of the record pits at the plurality of steps, thereby improving the accuracy of power calibration.

To the end, according to the invention, there is provided an information record method for adjusting power of write light onto an optical information record medium, the information record method comprising the steps of recording a record pit in the optical information record medium by applying write light of specific power or predetermined power emitted from a light source and extracting feature information of the record state containing the recorded record pit based on the signal waveform

provided by optically reproducing the record state, setting write light of a plurality of steps of power based on the feature information, then recording record pits at a plurality of steps in the optical information record medium by applying the write light of the plurality of steps of power and extracting the feature information of the record state for each of the record pits at the plurality of steps based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, and determining that power of write light corresponding to the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is appropriate write light power, and adjusting the write light power.

According to the information record method of the invention, a record pit is recorded in the optical information record medium by applying write light of predetermined power, the feature information of the record state is extracted based on the signal waveform provided by optically reproducing the record pit in the record portion, and write light of a plurality of steps of power is set based on the difference between the feature information and the target feature information. Next, record pits at a plurality of steps are recorded in the optical information record medium by applying the write light of the plurality of steps of power, the feature information of the

record state for each of the record pits at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is appropriate write light power, and the emission power of the write light is adjusted.

To the end, according to the invention, there is provided an information record medium recording control information for controlling an information record apparatus for recording information by adjusting power of write light emitted from a light source, the control information for adjusting the power of the write light, the control information for controlling the information record apparatus, thereby recording a record pit in the optical information record medium by applying write light of specific power or predetermined power emitted from the light source and extracting feature information of the record state containing the recorded record pit based on the signal waveform provided by optically reproducing the record state, setting write light of a plurality of steps of power based on the feature information, then recording record pits at a plurality of steps in the optical information record medium by applying the write light of the plurality of steps of power

and extracting the feature information of the record state for each of the record pits at the plurality of steps based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, and determining that power of write light corresponding to information closest to or almost equal to target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is appropriate write light power, and adjusting the power of the write light emitted from the light source based on the determination result.

According to the information record medium of the invention, if the recorded control information is executed in an electronic machine such as a personal computer, it is made possible to emulate the function of the information record apparatus implemented as hardware and record information by applying write light of appropriate power.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram to show the configuration of an information record apparatus of an embodiment of the invention.

FIG. 2 is a drawing to show data stored in a storage section in the embodiment of the invention.

FIG. 3 is a drawing to show the format of a calibration

area of CD-R.

FIG. 4 is a flowchart to describe the operation of the embodiment of the invention.

FIG. 5 is a drawing to describe the principle for setting the optimum emission power in the embodiment of the invention.

FIG. 6 is a waveform chart to describe the principle for finding α value from HF signal.

FIG. 7 is a waveform chart to describe the principle for finding β value from HF signal.

FIG. 8 is a drawing to describe the principle for setting the optimum emission power in a related art.

FIG. 9 is a flowchart to describe a method for setting the optimum emission power in the related art.

DETALED DESCRIPTION OF THE PRESENT INVENTION

Referring now to the accompanying drawings, there is shown a preferred embodiment of the invention. FIG. 1 is a block diagram to show the configuration of an information record apparatus 1 of an embodiment.

In the figure, the information record apparatus 1 comprises a spindle motor 2, a pickup 3, and a carriage 4 on which the pickup 3 is mounted.

The spindle motor 2 is spindle-servoed by a servo circuit 5 and rotates a write-once or rewritable optical disk DSK placed at a clamp position at a predetermined linear speed.

The pickup 3 comprises a semiconductor laser (not shown), an optical system (not shown) comprising an object lens, and a photodetector (not shown) formed of a photodiode, etc.

To record information, write laser light of predetermined power optimized by light pulse strategy is emitted from the semiconductor laser and is made to converge by the optical system, whereby a write light beam is generated, and a spot of the write light beam is applied to the optical disk DSK through the object lens for forming a record pit in a record film of the optical disk DSK.

When information is reproduced, read laser light of predetermined power is emitted from the semiconductor laser and is made to converge by the optical system, whereby a read light beam is generated, and a spot of the read light beam is applied to the optical disk DSK through the object lens. Reflected light from the optical disk DSK is gathered by the optical system and a photoelectric conversion signal Sdt provided by executing photoelectric conversion of the reflected light by the photodetector is supplied to an RF amplification section 7. Accordingly, an HF signal SHF having information of the optical disk DSK is supplied from the RF amplification section 7 to an HF signal feature extraction section 6.

The above-mentioned light pulse strategy is a technique wherein record pits are formed in appropriate form by optimized laser light emitted from a semiconductor laser as the form of

a light pulse relative to the record mark length is adjusted, so that a high-quality reproduction signal with occurrence of jitter, etc., suppressed can be provided when information is reproduced.

The carriage 4 is carriage-servoed by the servo circuit 5 and moves the pickup 3 in the direction of the radius of the optical disk DSK.

The pickup 3 is provided with an actuator (not shown) for driving the object lens contained in the optical system and the servo circuit 5 controls the actuator, thereby performing focus servo and tracking servo.

In addition to the HF signal feature extraction section 6 and the RF amplification section 7, the information record apparatus 1 further comprises a decoder section 8, an output section 9, an input section 10, an encoder section 11, a record power adjustment section 12, a system controller 13, a storage section 14, and an operation/display section 15.

The system controller 13 has a microprocessor or microprocessing unit (MPU) and performs centralized control of the whole operation of the information record apparatus 1 in addition to control of power calibration described later by executing a predetermined system program.

The storage section 14 is implemented as nonvolatile memory of SRAM etc., and stores n pieces of variable data (Dc1k, Dc2k, …, Dcnk) to variably set the recommended emission power

of the semiconductor laser at n steps. In the embodiment, n=15 steps.

Further, the storage section 14 stores target β value data βk for each optical disk DSK type k, as shown in FIG. 2.

Here, the target β value data βk is data indicating each β value when calculation of the expression (1) shown above is performed based on the HF signal recorded in a state in which the record state of each type of optical disk satisfies the predetermined specification and a sufficient margin is taken for variations in record state; the target β value data βk is previously found by experiment. The letter k denotes the optical disk type.

The operation/display section 15 comprises an operation section for the user to perform entry operation of starting to record information, etc., and a display section for displaying the operation status, an operation menu, etc., of the information record apparatus 1.

The input section 10 performs preprocessing of converting an external input signal Sin at the information recording time into digital input data Din, etc., and the encoder section 11 EFM-modulates the digital input data Din, etc., thereby generating record data DWT.

The record power adjustment section 12 generates an optimum pulse by light pulse strategy from the record data DWT, generates a current Id of a pulse train based on the optimum

pulse, and supplies the current Id to the semiconductor laser in the pickup for emitting write laser light. The current value of the current Id is adjusted in accordance with specification from the system controller 13, whereby the emission power of the semiconductor laser is controlled.

When information is recorded, the record power adjustment section 12 generates the current Id of a pulse train by the light pulse strategy and drives the semiconductor laser in the pickup, thereby emitting pulse-like write laser light; when information is reproduced, the record power adjustment section 12 supplies a current Id of a constant value to the semiconductor laser, thereby emitting read laser light of constant power.

When the photoelectric conversion signal Sdt is supplied from the photodetector placed in the pickup 3 to the RF amplification section 7 and the HF signal SHF generated by the RF amplification section 7 based on the photoelectric conversion signal Sdt is supplied to the HF signal feature extraction section 6, the HF signal feature extraction section 6 detects levels of the waveform of the HF signal SHF. Top peak level a1 corresponding to the potential difference between the potential indicating the strength of reflected light from a land where no record pit is formed and the potential of AC ground GND and bottom peak level a2 corresponding to the potential difference between the potential indicating the strength of reflected light from a record pit and the potential of AC ground

GND are detected, as shown in FIG. 7, and the detection result of the top peak level a1 and the bottom peak level a2 is supplied to the system controller 13 as feature data DHF indicating the record state of the optical disk DSK.

The system controller 13 performs calculation of the expression (1) shown above based on the feature data DHF to find a β value.

The RF amplification section 7 generates the HF signal SHF and also generates an RF signal SRF from the HF signal SHF and supplies the RF signal SRF to the decoder section 8, which then performs processing of EFM demodulation, etc., for the RF signal SRF and supplies the result to the output section 9, which then performs processing of D/A conversion, etc., for the data from the decoder section 8 and outputs an output signal Sout.

The RF amplification section 7 generates an error signal of a focus error, a tracking error, and the like from the photoelectric conversion signal Sdt and supplies the error signal to the servo circuit 5, whereby various servos such as focus servo and tracking servo are performed.

Next, the operation of the described information record apparatus 1, mainly the operation for performing power calibration to optimize the emission power of the semiconductor laser placed in the pickup 3 will be discussed. The power calibration operation for recording information on CD-R will

be discussed as a typical example.

First, as shown in FIG. 3, in CD-R, a power calibration area PCA is previously allocated to a portion on the disk center side (at the inner radius of the optical disk) from a read-in area, and is made up of a test area TA and a count area CA.

The test area TA is provided for forming a record pit as trial write by write laser light emitted from the semiconductor laser. The count area CA is provided for counting the number of records already made in the test area TA, and one frame is recorded in response to one record (trial write).

FIG. 4 is a flowchart to describe the power calibration operation. When the user gives a record start command, power calibration is conducted under the control of the system controller 13.

In FIG. 4, first at step S100, the pickup 3 is moved to the count area CA for reproducing information. The HF signal SHF generated as the information is reproduced is checked.

Next, at step S102, a portion where data is already recorded is checked based on the provided HF signal SHF and a search is made for the location one frame before the already recorded portion.

Next, at step S104, the information record apparatus 1 is set to an information record mode and data is recorded by fixed recommended emission power Pk starting at the location one frame before the already recorded portion in the count area

CA. That is, as shown in FIG. 5 (A), data is recorded starting at the location one frame before the already recorded portion in the count area CA by the recommended emission power Pk of a constant value predetermined for CR-R.

The recommended emission power Pk can also be changed based on information previously written on the disk, etc.

Next, at step S106, the information record apparatus 1 is again set to an information reproduction mode and the data recorded in the count area CA is read. At step S108, β value βca is calculated based on the feature data DHF provided from the HF signal SHF.

Next, at step S110, the difference between the β value βca and the target β value βk is found and m steps of emission power corresponding to the difference value (βca-βk) are determined. That is, as shown in FIG. 5 (B), m recommended emission powers PL to PH preceding and following the recommended emission power Pk corresponding to the difference value (βca-βk) as the center are selected from among n recommended emission powers corresponding to the variable data pieces (Dc1l, Dc2l, …, Dcnl) in the storage section 14. In the embodiment, m is determined five (m=5).

Accordingly, as shown in FIG. 5 (C), m=five recommended emission powers PL to PH are selected from among the n=15 recommended emission powers corresponding to the variable data pieces (Dc1l, Dc2l, …, Dcnl) and further m=five variable data

pieces corresponding to the m=five recommended emission powers PL to PH are determined to be variable data for trial write.

For example, if the recommended emission power Pk corresponding to the difference value ($\beta ca-\beta k$) corresponds to variable data piece Dc17, variable data pieces (Dc15, Dc16, Dc17, Dc18, and Dc19) are determined to be variable data for trial write.

Next, at step S112, the pickup 3 is moved to the location of the test area corresponding to the data written into the count area CA.

Next, at step S114, the information record apparatus 1 is again set to the information record mode and the system controller 13 varies the emission power P of the semiconductor laser based on the variable data for trial write and writes record pits at m steps into the test area TA for a try. In the embodiment, trial write based on the variable data for trial write is executed three times.

That is, as shown as symbols PT1 to PT3 in FIG. 5 (A), when the first trial write PT1 is executed based on the variable data for trial write, subsequently the second trial write PT2 is executed based on the variable data for trial write and further subsequently the third trial write PT3 is executed based on the variable data for trial write. Therefore, trial write of the record pits at m steps by the m steps of the emission powers PL to PH shown in FIG. 5 (C) is executed three times. Each

step of the emission powers PL to PH is every predetermined required time τ. Accordingly, three trial write portions REC1 to REC3 are formed in the test area TA of the optical disk, as shown in FIG. 5 (D).

For example, for CD-R, if the required time τ for one step is set to one ATIP frame and five steps are repeated three times for executing trial write in the test area TA of power calibration, three times at each step are separated almost at angles of 120 degrees each relative to the disk center and are averaged, whereby it is made possible to cancel the effects of side run-out, eccentricity, etc., of the disk.

Next, at step S116, the information record apparatus 1 is again set to the information reproduction mode and the three trial write portions REC1 to REC3 are read, whereby reference data DHF having information in each of the trial write portions REC1 to REC3 is acquired. Next, at step S118, β values (β11 to β1m), β values (β21 to β2m), and β values (β31 to β3m) corresponding to the trial write portions REC1 to REC3 are calculated based on the reference data DHF. That is, the m β values (β11 to β1m) are calculated based on the m reference data pieces DHF provided corresponding to the trial write portion REC1, the m β values (β21 to β2m) are calculated based on the m reference data pieces DHF provided corresponding to the trial write portion REC2, and the m β values (β31 to β3m) are calculated based on the m reference data pieces DHF provided corresponding

to the trial write portion REC3.

Next, at step S120, average values of the β values, $\beta AV1$ to βAVm, are calculated for each of m steps of the β values ($\beta 11$ to $\beta 1m$), ($\beta 21$ to $\beta 2m$), and ($\beta 31$ to $\beta 3m$) as shown in the following expressions (2-1) to (2-m):

$$\beta AV1 = (\beta 11+\beta 21+\beta 31)/3 \qquad (2\text{-}1)$$

$$\beta AV2 = (\beta 12+\beta 22+\beta 32)/3 \qquad (2\text{-}2)$$

$$\beta AVm = (\beta 1m+\beta 2m+\beta 3m)/3 \qquad (2\text{-}m)$$

Next, at step S122, whether or not the target β value βk lies in the range of the average values $\beta AV1$ to βAVm is determined. If the target β value βk lies in the range (Yes at step S122), control goes to step S124 and the emission power corresponding to the average value closest to the target β value βk, of the average values $\beta AV1$ to βAVm is determined the optimum emission power Popt and further the variable data for trial write corresponding to the optimum emission power Popt is adopted as the data to set the optimum emission power (optimum data).

Next, at step S124, the optimum data is stored in the storage section 14 as history data and then is supplied to the record power adjustment section 12, whereby an instruction is given so as to adjust the drive current Id based on the optimum data when actual information recording is executed, the pickup

3 is moved to the program area of the optical disk DSK, and a wait is made until actual information recording is started. The power calibration is now complete.

On the other hand, if the target β value βk does not lie in the range of the average values βAV1 to βAVm (No) at step S122, control goes to step S126 to again conduct the power calibration from the beginning, and the m steps of the emission powers PL to PH determined at the preceding time are adjusted so as to provide the target β value, thereby determining new m steps of emission powers PL to PH for trial write. In the adjustment at step S126, the m steps of emission powers PL to PH for trial write are finely adjusted in a predetermined amount at a time.

The processing at steps S112 to S122 is repeated. In the repetitive processing, at step S114, trial write into the test area TA is executed based on the m steps of emission powers PL to PH for trial write finely adjusted, the trial write portions are read at step S116, β values are calculated based on the HF signals SHF provided by reading the trial write portions at step S118, new average values βAV1 to βAVm are calculated based on the β values at step S120, and whether or not the target β value βk lies in the range of the new average values βAV1 to βAVm is determined at step S122.

If the average value closest to the target β value βk is found from among the average values βAV1 to βAVm by performing

the repetitive processing in the order of steps S100 to S104, S126, and S112 to S122, step S124 is executed and the power calibration is completed, as described above. Again if the target β value βk does not lie in the range of the average values βAV1 to βAVm, the repetitive processing is performed in the order of steps S100 to S104 and S120 and if the target β value βk lies in the range of the average values βAV1 to βAVm and the closest average value is found accordingly, the power calibration is completed.

As described above, according to the embodiment, recording in the count area CA is executed by the recommended emission power, m steps of emission power for trial write are determined based on the difference value between the β value and the target β value (βca-βk) provided by the recording, and trial write into the test area TA is executed by the emission power for trial write.

That is, the m steps of emission power for trial write are determined based on the difference value (βca-βk) provided from the record portion based on the recommended emission power Pk in the count area and thus the emission power for trial write to record in the test area TA is preset to a value close to the optimum emission power.

Thus, in the embodiment, the optimum emission power Popt can be found at higher speed as compared with case where trial write into the test area TA is executed based on a large number

of steps (n=15) of emission power and is repeated until the target β value is obtained as in the related art. Further, recording in the test area TA is executed based on a limited number of m steps of emission power for trial write less than the number of steps n and thus the power calibration area can be saved and the optimum emission power Popt can be found at higher speed.

Further, for example, if eccentricity, side run-out or occurs on the optical disk during the trial write, a plurality of pits are recorded in the test area TA based on the emission power for trial write and the optimum emission power Popt is determined based on the average value of the β values provided by recording the pits and thus the optimum emission power Popt can be found at higher speed without being affected by side run-out or occurs on the optical disk.

In the embodiment, the β value is adopted as the optimization condition, but the invention is not limited to it. The value of asymmetry of the waveform itself of HF signal SHF as shown in FIG. 6 may be applied as the feature information for optimization in place of the β value.

That is, as shown in FIG. 6, top peak level a1 of the HF signal SHF corresponding to the strength of reflected light from a land where no record pit is formed in optical disk, bottom peak level a2 corresponding to the strength of reflected light from a large record pit, top peak level b1 corresponding to

the strength of reflected light from a land between small record pits, and bottom peak level b2 corresponding to the strength of reflected light from a small record pit are detected and the detected levels a1, a2, b1, and b2 are applied to the following expression (3), thereby finding the value of asymmetry, which will be hereinafter referred to as α value:

$$\alpha = \{(a1+a2) - (b1+b2)\}/\{2 \times (a1-a2)\} \qquad (3)$$

The target α value data corresponding to each type of disk is previously stored in the storage section 14 in place of the target β value data βk, and the α values may be applied in the processing shown in FIG. 4, 5 in place of the β values for performing the power calibration.

Modulation depths may be adopted as the optimization condition in place of using the β values as the optimization condition.

That is, modulation depth M found by detecting the top peak level a1 and the bottom peak level a2 of the HF signal SHF output from the RF amplification section 7 and performing calculation of the following expression (4) may be adopted as the optimization condition:

$$M = (a1-a2)/a1 \qquad (4)$$

The target modulation depth data corresponding to each type of disk is previously stored in the storage section 14 in place of the target β value data βk, and the modulation depths may be applied in the processing shown in FIG. 4, 5 in place of the β values for performing the power calibration.

Further, in the embodiment described above, the information record apparatus implemented as hardware has been described, but the invention is not limited to it. For example, the hardware configuration of the information record apparatus of the embodiment may be implemented as a computer program (emulator) and an electronic machine containing a microprocessor, such as a personal computer, may be controlled based on the computer program for delivering functions equal to those of the information record apparatus implemented as hardware.

The computer program may be recorded on an information record medium, such as CD (compact disk) or DVD (digital video disk or digital versatile disk), as an application file and the application file may be installed in or downloaded into an electronic machine such as a personal computer capable of playing back the information record medium for executing the computer program.

As described above, according to the invention, recording on an optical disk is executed by applying the write light of

the predetermined power, whereby write light of the plurality of steps of power for trial write to determine appropriate write light power are determined, and trial write onto the optical disk is executed by applying the write light of the plurality of steps of power, the feature information of the record state for each of the record pits at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states containing the record pits at the plurality of steps, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the feature information of the record state for each of the record pits at the plurality of steps is the appropriate write light power, and the emission power of the write light is optimized, so that it is made possible to save the power calibration area and the time required for the power calibration can be shortened.

A plurality of sets of record pits at a plurality of steps are written for a try in the optical disk by applying the write light of the plurality of steps of power, the feature information of the record state for each of the record pits in the plurality of sets and at the plurality of steps is extracted based on the signal waveform provided by optically reproducing the record states containing the plurality of sets of the record pits written for a try, average feature information of the record state for each of the record pits at the plurality of steps

is found, it is determined that power of write light corresponding the information closest to or almost equal to the target feature information, of the average feature information is appropriate write light power, and the emission power of the write light is optimized. Thus, the effects of side run-out, eccentricity, unevenness, etc., of the optical information record medium can be suppressed and the accuracy of the power calibration can be improved.